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for Leaches Bay Substation
Upgrade: 132/11kV
Transformer 3 Bay**

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EXECUTIVE SUMMARY

The objective of this design phase is to get Eskom Distribution to approve the proposed detailed design for the upgrade of Leaches Bay substation 132/11kV transformation capacity. Leaches Bay Substation is currently equipped with 2x20MVA 132/11kV Transformers and has been designed to accommodate 3x40 MVA 132/11kV Transformers, which could ultimately provide a firm 80MVA Bulk 11kV Supply Capacity. The 11kV Medium Voltage network feeds the ELIDZ. Leaches Bay substation has fourteen (14) 11kV feeder capacity. Twelve (12) feeders are utilised to supply ELIDZ and two to supply Buffalo City Metro (BCM) load, therefore leaving no spare feeders. The current ELIDZ electrical network is divided into four supply zones with limited interconnection between them. Each zone has a dedicated switching station from which all its MV/LV substations are connected. Zone 1A has two switching stations due to its high electricity demand and available land still to be developed. This project is required to allow Leaches Bay substation to supply the additional load demand via its 11kV feeders to the ELIDZ as outlined in the customer's application. For Leaches Bay to supply additional load to the ELIDZ, the present design calls for the establishment of 40MVA transformer to the spare transformer bay as shown below:

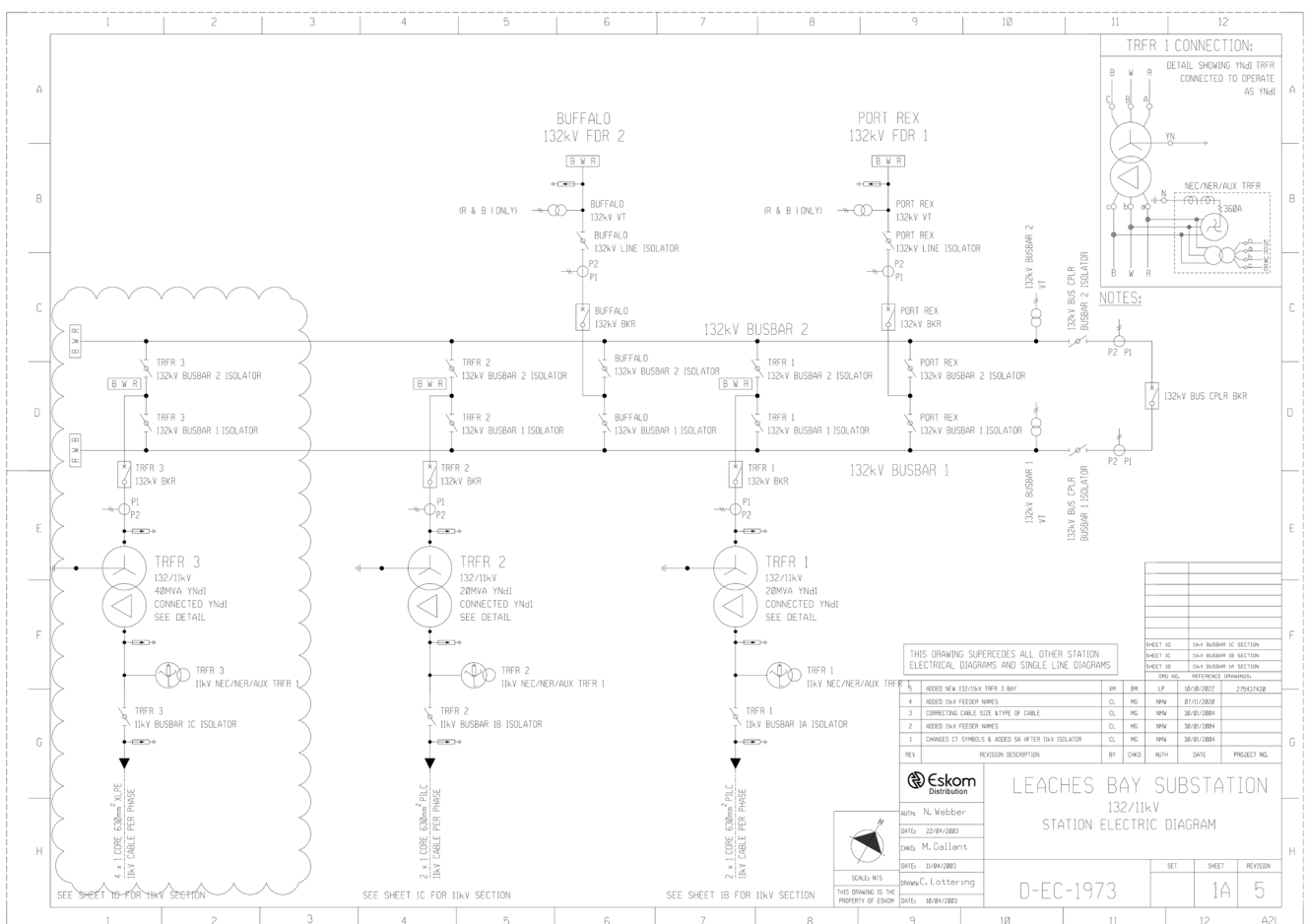


Figure 1: Leaches Bay Substation HV Station Electric Diagram with a 3rd 40MVA transformer bay

The short-term forecasted load for ELIDZ is estimated at 32 MVA with long term forecasted load at approximately 80 MVA. The existing capacity of 2x20 MVA is not sufficient to meet a future load with the current installed capacity. To ensure that future load requirements are met, a 3rd 40 MVA transformer bay, transformer MV board feeder, Bus-section and 2x transfer feeder to feed the 11 kV Busbar 1A will be added to the existing primary plant with the objective of adhering to Eskom specifications and standards.

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1. INTRODUCTION

This document provides design status information of the completed detailed design phase for a 40MVA firm capacity increase at Eskom leaches bay substation via self-build application process. This document is a major input to the formal design review process at the end of the detailed design phase and describes the design process followed and technical output of the detailed phase. The document contents provide an overview of the outcome of the design related activities with references to design and other documents when further detail information is required.

The purpose of the detailed design phase is to:

1. Establish a complete design, i.e. to produce all the component specifications, engineering drawings and other design documentation for procurement, fabrication, installation, construction and commissioning;
2. Ensure integration (utilities, mass and energy, system control, interfaces, etc.) of sub-system detail designs;
3. Finalise the layout designs with actual component data as input and resolve clashes;
4. Consolidate and standardise bulk items for procurement;
5. Formalise the acceptance test procedures for product validation; and
6. Develop construction, installation and commissioning procedures.

1.1 SYSTEM IDENTIFICATION

Project Name	Job Names
Leaches bay substation upgrade : 132/11kV Transformer 3 Bay	275437420: Leaches Bay Substation - Install a 3 rd transformer bay (Contract Works)

1.2 SYSTEM OVERVIEW

In this detailed design, Leaches bay substation constitutes a supply point for ELIDZ at 11 kV through T1, T2 and T3 transformers. Adding of T3 transformer bay in this existing substation entails the following changes:

- (1) Meet the minimum Eskom requirements, including:
 - a) Additional one 11 kV feeder bay for ELIDZ
 - b) Substation capacity increase will accommodate future exponential growth.
- (2) Maintain maximum reliability by retaining as much of the existing infrastructure as possible;
- (3) Preservation of majority of switching station.

This solution will enable the safe completion of all the construction works inside the existing Eskom substation boundary. Four outages will be arranged: the first one is the extension of the 132 kV busbar; the second is the installation of a 132/11 kV 40 MVA transformer; the third is the 11 kV bus section, transformer incomer, and outgoing transfer feeder 16; and the fourth involves the installation of the 11 kV outgoing transfer feeder 15.

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2. SUPPORTING CLAUSES

2.1 SCOPE

This document provides an overview of the engineering processes followed and the system design status at the end of the detailed phase. The document describes the results of technical assessments, compliance with stakeholder requirements and technical risks identified for this design phase. This document further provides references to approve the design output documentation.

The battery limits for this document are as follows:

- The new 3rd transformer bay at Leaches Bay Substation;
- Extension of 11 kV Board;
- Control plant additions.

This document does not provide design cost or other project management information.

2.1.1 Purpose

This document summarises the status and outcome of the detailed phase design related activities and describe the achievement of the design goals in terms of meeting the stakeholder requirements. This document, together with the design output documentation of this design phase, is submitted for review and approval as pre-requisite for construction.

2.1.2 Applicability

This document is applicable to the Design Review Team (DRT) for the review and the project team involved in the detail design review of self-build projects for Bulk Power supply within the Eskom Distribution Eastern Cape Operating Unit (ECOU).

2.2 NORMATIVE / INFORMATIVE REFERENCES

2.2.1 Normative

The following documents are indispensable for the application of this document and are used in conjunction with this document.

- [1] 240-71062174 - Generic Substation Design
- [2] 240-68971972 - Standard for Stranded Flexible Conductor Selection
- [3] 240-56364444 - Standard Minimum Requirements for the Metering of Electrical Energy and Demand
- [4] 240-76628315 - Protection Design Philosophy for Medium Voltage Distribution Networks
- [5] 240-84854878 - Specification for Distribution Protection Schemes: Transformers

2.2.2 Informative

The following documents are further sources of information referenced in this report.

- [1] 240-68972408 – Standard for Flexible and Tubular Conductor Heights and Phase Spacing
- [2] 240-83382076 – Standard for Operational Floodlighting in Substations
- [3] 240-87605434 – Quality Checklist for Distribution Substation Primary Plant Prior to Handing Over for Commercial Operation.
- [4] 240-64100247 – Standard for Earthing of secondary plant equipment in substations

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- [5] 240-120804300 – Standard for the labelling of electrical equipment within Eskom wires networks
- [6] 240-122922894 – Technical evaluation standards for substation tubular conductors
- [7] 240-68972068 – Standard for tubular conductor selection
- [8] 240-108982466 – Standard for HV Yard stones in Substations
- [9] 240-84854974 – Continuity measurement of substation earth grid system
- [10] 240-109589380 – Direct Lightning Stroke Protection of Substations

2.3 DEFINITIONS

2.3.1 Classification

Controlled disclosure: controlled disclosure to external parties (either enforced by law, or discretionary).

2.4 ABBREVIATIONS

In the following table lists and describes all abbreviations commonly used by Eskom as well as those used in the document, in alphabetical order.

Abbreviation	Description
ASCR	Aluminium Conductor Steel Reinforced
BQ	Budget Quote
C&I	Control and Instrumentation
CDR	Concept Design Report
CEL	Cost Estimate Letter
COUE	Cost of Unserved Energy
CRA	Concept Release Approval
DDR	Detail Design Report
DHO	Design Hand-Over
DRA	Definition Release Approval
DRT	Design Review Team
DS	Distribution Station
Dx	Distribution
EO	Environmental Officer
ERA	Execution Release Approval
FRA	Finalisation Release Approval
ECOU	Eastern Cape Operating Unit
LF	Load Factor
OEM	Original Equipment Manufacturer
PARICS	Participate, Accountable, Responsible, Inform, Consult, Sign-Off

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PDE	Power Delivery Engineering
PEM	Project Evaluation Model
PF	Power Factor
PCC	Point of Common Coupling
POC	Point of Connection
POM	Point of Measurement
PUC	Point of Utility Connection
RACI	Responsibility, Accountability, Consult and Inform
SAHRA	South African Heritage Resources Authority
SANRAL	South African National Roads Agency
SHE	Safety, Health & Environmental
SOW	Scope of Work
SRD	Stakeholders Requirements Definition
S/S	Substation

3. DETAILED DESIGN INFORMATION

Through various meeting with stakeholders, the design team was able to produce this detailed design herein and for which the detail is provided below.

3.1 OBJECTIVE OF THE DETAIL DESIGN PHASE

Eskom has approved the installation of the 3rd transformer bay at leaches bay substation in order to increase the firm capacity from 20MVA to 40MVA to support load growth at ELIDZ. The Objective of the detailed design is to demonstrate the implementation of the solution on the existing site.

3.2 SCOPE OF DETAILED DESIGN

The following section provides a view of the design work carried put herein:

- Design 3rd transformer bay
- Design transformer incomer, bus section and 2x11kV transfer feeders

The above design considers all aspects of a substation including but not limited to the electrical, mechanical and civil engineering.

3.3 KEY DESIGN CONSIDERATIONS

In order to complete the present detailed design, the following assumptions and considerations apply. There is an existing earthmat where the new transformer bay will be installed. Hence, all the new equipment are to be earthed using the foundation HD bolts to the existing earthmat.

3.4 DESIGN APPROACH

The detailed design covers the following steps:

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- Load forecast and fault level analysis;
- Stakeholders engagement;
- Joint site visits between Bigen Engineers and Eskom;
- Clarification meetings between Bigen and Eskom;
- Clarification and progress meetings between Bigen and the client (ELIDZ);
- Equipment selection and specifications.

3.4.1 Design criteria

The design criteria adopted are:

- Transformers, conductors and cables do not exceed their thermal rating;
- Cables and conductor ratings remain less or equal to their respective thermal ratings;
- Each equipment's compatibility and short-circuit withstanding capabilities are sufficient to withstand the substation's prospective short circuit.

Information received from Eskom show fault levels as indicated on the following table.

Table 1: Fault levels at Leaches Bay Substation

Fault level scenarios	Normal network configuration post commissioning of IPP	Minimum (one trfr or line out on Tx or Dx network)	Maximum (includes future strengthening and generation)	Breaker rating (kA)
Scenario detail	Existing network with the 2x20 MVA 132/11kV parallel and 40 MVA 132/11 kV unparallelled	Buffalo/Leaches Bay 132 kV line out	Port Rex Generation on	
Leaches Bay Substation 132kV				
3ph (kA)	9.9	5.8	10.9	40
1ph (kA)	10.7	6.7	11.4	
Leaches Bay Substation 11kV (1A)				
3ph (kA)	18.6	16.7	18.9	20
1ph (kA)	0.8	0.8	0.8	
Leaches Bay Substation 11kV (1B)				
3ph (kA)	18.6	16.7	18.9	20
1ph (kA)	0.8	0.8	0.8	
Leaches Bay Substation 11kV (1C)				
3ph (kA)	18.5	16.5	18.7	20
1ph (kA)	0.4	0.4	0.4	

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3.4.2 Design Inputs

The design inputs started with a client (ELIDZ) User Requirement Specification that captured the following information:

- The load lists (Signed Off)
- Operational requirements (Voltages – Signed Off)
- Application for the increase of the firm capacity from 20MVA to 40MVA at leaches bay substation from Eskom Distribution East London Office (Signed off and cost estimates paid (Approved and Paid)
- Project kick off meeting (Eskom (Various Departments) and Bigen (Project management and Engineering team)
- Project scoping meeting with Eskom (Primary Plant and Secondary Plant) and Bigen (Project Management and Engineering Team)
- Project scoping and alignment meeting with Eskom, ELIDZ and Bigen (An alignment was reached between the three parties);

3.4.3 Design Process

Considering the design input and criteria, the design proceeded as follows:

- Load flow to confirm the thermal loading of the new transformer bay (transformer capacity transfer between 132 kV and 11 kV);
- Short-circuit calculation to ensure that no excessive fault can potentially flow through any equipment;
- Identify and define the requirement to integrate secondary of control plant into the design.

From the above, appropriate equipment was selected in terms of thermal rating, short-circuit withstand capability and the voltage drop.

3.4.4 Design Outputs

From the detailed design, the following output is provided:

- Station Electric Diagrams;
- General Arrangement;
- Steelwork layout
- Section views for the primary plant;
- Foundation layout;
- Earthmat layout;
- Lighting and Lightning protection layout.

3.4.5 Design Verification

The following is summary description of the verification performed on the design:

- Client review of the User requirement Specification;
- Power System Analysis and Conductor and Voltage selection studies (Internal Review);
- Substation General Arrangement and Equipment Selection (primary and Secondary) (Eskom Distribution On-Site Discussions and reviews);
- Clearance coordination using the general arrangement and section view of transformer and feeder bay;
- Conceptual design presentation to Eskom.

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3.4.6 Codes and Standards

The design for the new transformer bay has been carried out in accordance but is not limited to the following applicable South African codes, local codes and ordinances, Eskom specific codes & standards, and international codes:

Document	Title
ISO 9001	Quality Management Systems
IEEE 81	Guide for measuring earth resistivity, ground impedance and earth surface potentials of a grounding system
SANS 121	Hot dip galvanized coatings on fabricated iron and steel articles – Specifications and test methods
SANS 282	Bending dimensions of bars for concrete reinforcement
SANS 1186	Symbolic safety signs (App)
SANS 1200A	Standardized specifications for civil engineering construction – A General
SANS 1200AA	Standardized specifications for civil engineering construction – AA General (small works)
SANS 1200C	Standardized specifications for civil engineering construction – C Site Clearance
SANS 1200D	Standardized specifications for civil engineering construction – Earthworks
SANS 1200DA	Standardized specifications for civil engineering construction – Earthworks (small works)
SANS 1200DB	Standardized specifications for civil engineering construction – DB Earthworks (pipe trenches)
SANS 1200DK	Standardized specification for civil engineering construction – DK Gabions and pitching
SANS 1200DM	Standardized specifications for civil engineering construction – DM Earthworks (road, subgrade)
SANS 1200G	Standardized specifications for civil engineering construction – G Concrete (structural)
SANS 1200GA	Standardized specifications for civil engineering construction – GA Concrete (small works)
SANS 1200GB	Standardized specifications for civil engineering construction – GB Concrete (ordinary buildings)
SANS 1200H	Standardized specifications for civil engineering construction – H Structural steelwork
SANS 1200HA	Standardized specifications for civil engineering construction – HA Structural steelwork (sundry items)
SANS 1200HC	Standardized specifications for civil engineering construction – HC Corrosion protection of structural steelwork
SANS 1200LB	Standardized specifications for civil engineering

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	construction – LB Bedding (pipes)
SANS 1200LE	Standardized specifications for civil engineering construction – LE Stormwater Drainage
SANS 1200M	Standardized specifications for civil engineering construction – M Roads (general)
SANS 1200ME	Standardized specifications for civil engineering construction – ME Subbase
SANS 1200MF	Standardized specifications for civil engineering construction – MF Base
SANS 1200MK	Standardized specifications for civil engineering construction – MK Kerbing and Channelling
SANS 1200MM	Standardized specifications for civil engineering construction – MM Ancillary roadworks
SANS 10103	The measurement and rating of environmental noise with respect to annoyance and to speech communication
SANS 10144	Detailing of steel reinforcement for concrete
SANS 10164	The structural use of masonry – All parts
SANS 10199	The design and installation of an earth electrode
SANS 10280-1	Overhead power lines for conditions prevailing in South Africa – Part 1: Safety
SANS 10400-T	The application of the National Building Regulations –Part T: Fire protection
SANS 60060-1	High-voltage test techniques – Part 1: General definitions and test requirements
32-95	Environmental, Occupational Health and Safety Incident Management Procedure
34-195	Standard Drawing Practice for Cad Users in the Power Plant and Control Plant Technologies Environments and for Electrification Networks
34-1985	Distribution Standard – Part 2, Earthing Section 1. MV and LV reticulation earthing
240-55922824	Substation Layout Design Guide
240-65216546	Standard for Portable Earthing Gear
240-68971854	Standard for Power Frequency Electric and Magnetic Analysis in Substations
240-72597722	Environmental Impact Assessment for Distribution Activities
240-75660336	Substation and Network Equipment Label Specification
240-76613395	Planning Standard for Distribution Network Reliability to Ensure Distribution Network Code Compliance
240-78980848	Specification for Nonlethal Energized Perimeter

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	Detection System (NLEPDS) for Protection of Eskom Installations and its Subsidiaries
240-84854974	Continuity Measurement of Substation Earth Grid Systems
240-87605434	Quality Checklist for Distribution Substation Primary Plant Prior to Handing Over for Commercial Operation
240-91252455	Lighting for Perimeter Security at Eskom Installations
240-96393507	Soil Resistivity Testing for Substation Applications
240-101940513	Substation Earth Electrode Resistance Measurement
240-109589380	Direct Lightning Stroke Protection of Substations
240-113163905	LED Floodlights for Distribution Substation Applications
240-120804300	Standard for the Labelling of Electrical Equipment within Eskom Wires Networks
240-122922610	Specification for Substation Tubular Conductors
240-134369472	Substation Earth Grid Design Standard

3.5 KEY DESIGN DRIVERS

The key design driver is to design a system that is technically and economically efficient and conforms to Eskom Distribution approved materials. The design of the new transformer bay is determined by the required rating of the new 40MVA 132/11kV transformer and Eskom Substation standards. Careful consideration was given to the layout of the proposed new transformer bay to ensure easy access for construction equipment and maintenance vehicles.

3.6 PRIMARY PLANT DESIGN

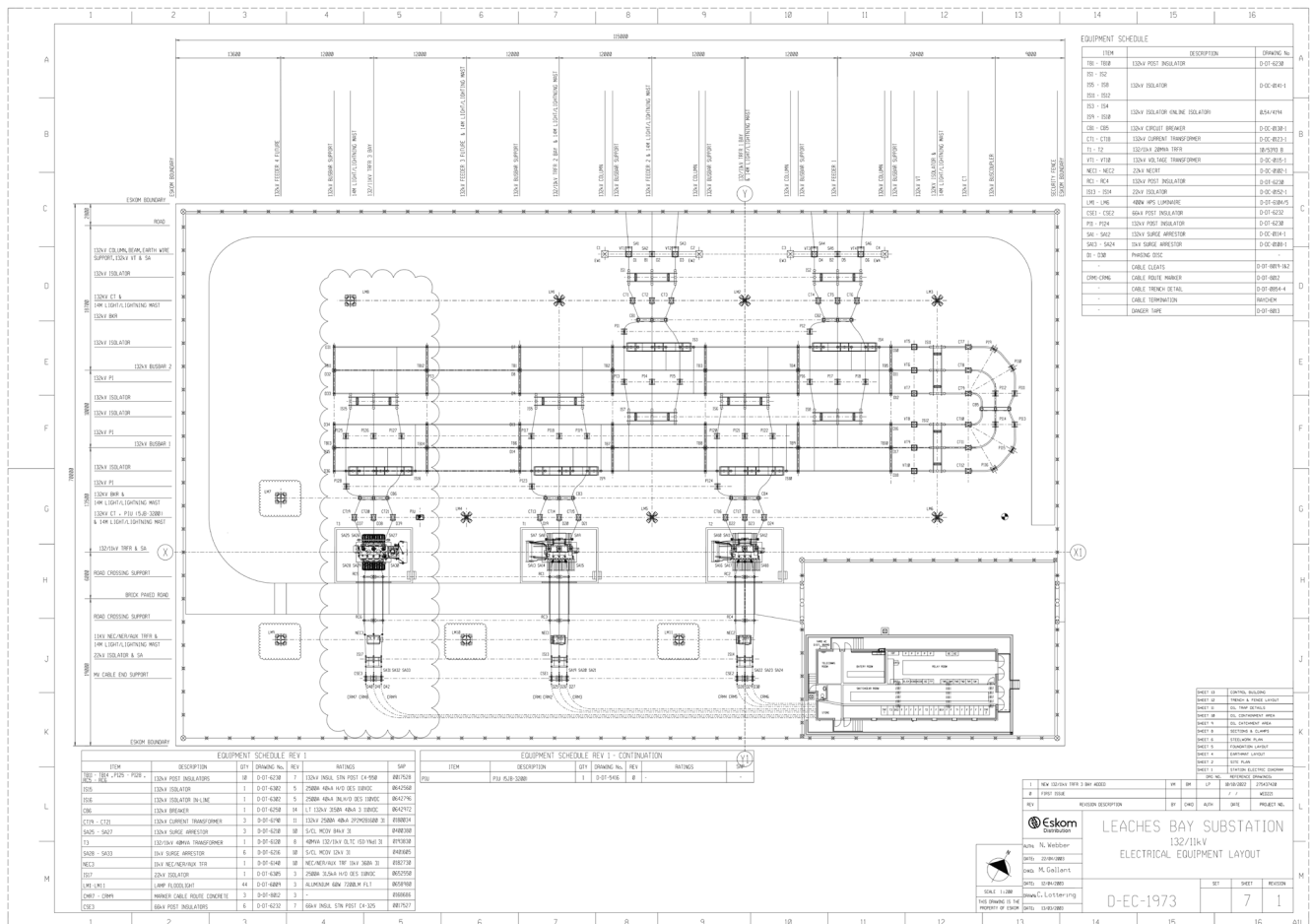
3.6.1 System Architecture

Recalling that the design is interested only with the 132 kV and 11 kV side of transformer T3, the general arrangement of Figure 2 shows the addition of the new 40MVA transformer bay in the substation.

On the 132 kV side of the transformer T3, there is tubular busbars, busbar isolators, circuit breaker, post insulators and post type current transformers. On the 11 kV side, there is a NECRT, Isolator and a cable end support connecting the cable to the transformer incomer board in the control room.

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3.6.2 Electrical System Design

The main components for the new transformer bay shown in Figure 2 above are as follows.

Table 2: Leaches bay additional equipment

EQUIPMENT	RATING
1 x Power Transformer	D-DT-6120, SAP number 0193830. ✓ Rated Power – 40 MVA ✓ Primary Voltage – 132 kV ✓ Secondary Voltage – 11 kV ✓ Vector Group – YNd1 ✓ Tap Changer – 25 kA ✓ Creepage – 31 mm/kV ✓ Standard Impedance – 10%
3 x Surge Arresters (To be installed on the 132kV side of the transformer)	Station Class D-DT-6210, SAP number 0400380. ✓ Rated Voltage – 132 kV ✓ Minimum MCOV – 84 kV ✓ Creepage – 31 mm/kV
1 x Inline Isolator	Double Side Break Isolator D-DT-6302, SAP number 0642796. ✓ Rated Voltage – 132 kV ✓ Rated Current – 2 500 A ✓ Rated Fault Current – 40 kA ✓ Creepage – 31 mm/kV
1 x Isolator	Double Side Break Isolator D-DT-6302, SAP number 0642560. ✓ Rated Voltage – 132 kV ✓ Rated Current – 2 500 A ✓ Rated Fault Current – 40 kA ✓ Creepage – 31 mm/kV
1x Circuit Breaker	D-DT-6250, SAP number 0642972. ✓ Rated Voltage – 132 kV ✓ Rated Current – 3 150 A ✓ Rated Fault Current – 40 kA ✓ Creepage – 31 mm/kV
10x Post Insulators	D-DT-6230, SAP number 0017528. ✓ Rated Voltage – 132 kV ✓ Creepage – 31 mm/kV
3x Current Transformers	D-DT-6190, SAP number 0180034. ✓ Rated Voltage – 132 kV ✓ Rated Current – 2 500 A ✓ Rated Fault Current – 40 kA / 3sec. ✓ Creepage – 31 mm/kV

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	✓ 6 Cores : 2 Protection – Class PX (MR) 2 Metering – Class 0.2 (MR) 2 Buszone – 1/1600T Class PX (MR)
1x NECRT	D-DT-6140, SAP number 0182730. ✓ Primary Voltage – 11 kV ✓ Secondary Voltage – 400 V ✓ Neutral Current – 360 A ✓ Creepage – 31 mm/kV
6x Surge Arresters (Three to be installed on the 11kV side of the transformer and the other three on the 22kV isolator)	Station Class D-DT-6216, SAP number 0401605. ✓ Rated Voltage – 11 kV ✓ Minimum MCOV – 12 kV ✓ Creepage – 31 mm/kV
1x Isolator	Double Side Break Isolator D-DT-6305, SAP number 0642550. ✓ Rated Voltage – 22 kV ✓ Rated Current – 2 500 A ✓ Rated Fault Current – 31.5 kA ✓ Creepage – 31 mm/kV
6x Post Insulators (To be installed on the cable end support)	D-DT-6232, SAP number 0017527. ✓ Rated Voltage – 66 kV ✓ Creepage – 31 mm/kV

Table 3: Leaches bay main equipment (Indoor)

EQUIPMENT	RATING
3x Circuit Breakers (For Transformer incomer and the two transfer feeders)	Vacuum Type D-DT-6258, SAP number 0170210. ✓ Rated Voltage – 11 kV ✓ Rated Current – 2 500 A ✓ Rated Fault Current – 25 kA
1x Busbar Circuit Breaker	Vacuum Type D-DT-6258, SAP number 0170209. ✓ Rated Voltage – 11 kV ✓ Rated Current – 2 500 A ✓ Rated Fault Current – 25 kA
3x Current Transformers (For Transformer Incomer Breaker Feeder)	Ring Type ✓ Rated Voltage – 11 kV ✓ Rated Current – 2 500 A ✓ Rated Fault Current – 25 kA ✓ Core – 3P ✓ Class – PX ✓ Ratio – 2400/1 MR
6x Current Transformers (For Transfer Breaker Feeders)	Ring Type ✓ Rated Voltage – 11 kV

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	<ul style="list-style-type: none"> ✓ Rated Current – 2 500 A ✓ Rated Fault Current – 25 kA ✓ Core – 3P ✓ Class – PX ✓ Ratio – 2400/1 MR
1x Voltage Transformer (For 11kV Busbar)	Busbar Type D-DT-6175, SAP number 0239686. <ul style="list-style-type: none"> ✓ Rated Voltage – 11 kV ✓ Rated Current – 2 500 A ✓ Rated Fault Current – 25 kA ✓ Class – 3P/0.2 ✓ Burden – 50 VA ✓ Ratio – 11 kV/110 V

3.6.3 Equipment rating verification

A verification comprising of check the sizing of major equipment is summarised in the following table.

Table 4: Equipment rating verification

Substation parameters	Unit	Value	Note	Adequacy
Power Transformer				
Rated transformer power	MVA	40	Supplied by Actom	
Rated transformer primary voltage	kV	132		
Rated transformer secondary voltage	kV	11		
<i>Primary current</i>	A	174.95		
<i>Secondary current</i>	A	2099.46		
Fault level-3ph @132 kV	kA	9.9	Supplied	
Fault level-1ph @132 kV	kA	10.7	Supplied	
Fault level-3ph @11 kV (1C)	kA	18.5	Supplied	
Fault level-1ph @11 kV (1C)	kA	0.4	Supplied	
11 kV Cable Selection				
Cross section	mm ²	630		
Nature		Cu		
Insulation		XLPE		
Number of Core		1C		
Short-circuit withstanding capacity Symmetrical (250°C)	kA (1s)	87.5	CBI-African cable	Sufficient to withstand the prospective short circuit current of 18.5 kA
Short-circuit withstanding capacity Earth fault (200°C)	kA (1s)	30.2	CBI-African cable	Sufficient to withstand the prospective short circuit current of 0.4 kA

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Rated current (ground)	A	665	CBI-African cable	
Bedding radius	mm	22.98		
<i>Number of Cable/Phase</i>		4		
Total current as per No. of Cable/P	A	2660		Sufficient to sustain In of 2 099.46 A
Voltage Drop Calculation				
Distance	m	100		
Impedance	Ohm/km	0.108		
Voltage drop	V	39.273		
Voltage drop	%	0.357		Acceptable (<5%)
Main Equipment (outdoor)				
132 kV Breaker				
Rated Voltage	kV	132		
Nominal Current	A	3150		Sufficient to sustain In of 174.95 A
Short-circuit withstand capacity	kA	40		Sufficient to withstand the prospective short circuit current of 9.9 kA
132 kV Isolator				
Rated voltage	kV	132		
Nominal current	A	2500		Sufficient to sustain In of 174.95 A
Short-circuit withstand capacity	kA	40		Sufficient to withstand the prospective short circuit current of 9.9 kA
132 kV CT				
Rated Voltage	kV	132		
Nominal Current	A	2500		Sufficient to sustain In of 174.95 A
Short-circuit withstand capacity	kA	40		Sufficient to withstand the prospective short circuit current of 9.9 kA
22 kV Isolator				
Rated voltage	kV	22		
Nominal current	A	2500		Sufficient to sustain In of 2099.46 A
Short-circuit withstand capacity	kA	31.5		Sufficient to withstand the prospective short circuit current of 18.5 kA
Main Equipment - Indoor				
11 kV Circuit Breakers				
Rated Voltage	kV	11		
Nominal Current	A	2500		Sufficient to sustain In of 2099.46 A

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Sort-circuit withstand capacity	kA	25		Sufficient to withstand the prospective short circuit current of 18.5 kA
11 kV CT				
Rated Voltage	kV	11		
Nominal Current	A	2500		Sufficient to sustain In of 2099.46 A
Short-circuit withstand capacity	kA	25		Sufficient to withstand the prospective short circuit current of 18.5 kA
Conductors				
Bull AAC				
Bay	kV	132		
Rated Current	A	1300		Sufficient to sustain In of 174.95 A
Burn off time	Sec	64.10		
Cross Section	mm ²	865.4		
Double Bull AAC				
Bay	kV	11		
Double Bull Conductor total current	A	2600		Sufficient to sustain In of 2099.46 A
Burn off time	Sec	18.35		
Cross Section for each	mm ²	865.36		
Centipede AAC				
Bay	kV	11		
Rated Current	A	833		
Cross Section	mm ²	415.22		
Hornet AAC				
Bay	kV	11		
Rated Current	A	457		
Cross Section	mm ²	157.95		

The 132 kV side of the transformer bay will be stringed with a single bull conductor while the 11 kV side of the transformer bay will be stringed with a double covered bull conductor. The same conductor is used for uniformity and spare. The hornet AAC conductor will be used for connecting the 11 kV Bull stringer onto the 11kV surge arrester and a covered centipede AAC conductor will be used for connecting the 11 kV bull stringer onto the NECR'T/AUX transformer.

The 4x 630mm² 1C XLPE cables/phase will be used for connection of the 11kV cable end support busbar onto the indoor 11kV incomer circuit breaker, the same cable size will also be used for the two transfer feeders.

The expected fault current is 9.9 kA on the 132 kV side primary (incoming) and 18.5 kA on the secondary (outgoing). To ensure that selected conductors can withstand the prospective short circuit of the substation.

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3.6.4 Clamps and Conductors Rating Verification

The clamp rated current values, the conductor rated current and tensile strength is summarised in the table below.

Table 5: Clamps and Conductors Rating Verification

Description	Rated Current (A)	Rated Tensile Strength (kN)
STRANDED CONDUCTOR CLAMPS		
LUG,AL HORNET 1B M12 0 DEG I/C		
CLAMP:EYC-T;COMP/PALM 90DG;2X38.3 MM	2700	
CLAMP:EX-C;BOLT/BOLT; STEM 38 COND 16.3	500	
CLAMP, PEG AL BULL 38.3mm EPC-38		
CLAMP:EX-D;BOLT/BOLT; STEM 38 COND 26.5	900	
CLAMP:EX-B;BOLT/BOLT; STEM 26 COND 26.5	900	
CLAMP:EYC-B;2X38.3 COMP 38 BOLTED 0DG	2500	
CLAMP:EXC-C;BOLT/COMP; STEM 38 COND38.3	1350	
CLAMP:EX-E;BOLT/BOLT; STEM 38 COND 38.3	1350	
CLAMP:EPC-D;COMP/PALM ODG;38.3 MM	1350	
CLAMP:EPC-E;COMP/PALM 45DG;38.3 MM	1350	
CLAMP:EXCP-D;PI MOUNT;38.3 MM;PCD 127		
CLAMP:EPC-F;COMP/PALM 90DG;38.3MM	1350	
TUBULAR CONDUCTOR CLAMPS		
CLAMP,TUBE:ETP-TE-IL2-R;120/2X38.3;0D	2700	
CLAMP,TUBE:ETEC-DC-C;120/4;38.3C-ENDCAP		
CLAMP,TUBE:ETEC-PL-C;120/4;PLAIN- ENDCAP		
TUBE:BUSBAR;LG 12 M;OD 120 MM;ID 112 MM	2300	
CLAMP,TUBE:ESC-PI-F-F;120/127;FIXED	3150	
CLAMP,TUBE:ESC-PI-S-F;120/127;SLIDE	3150	
CLAMP,TUBE:ETP-IL1-J;120/38.3;SINGLE	1350	
CLAMP,TUB BUS/PALM T/OFF TBPT120	1350	
CONDUCTORS		
COND, AAC HORNET 16.25D INSU UNGRS	457	26
COND, AAC CENTIPEDE 26.45D INSU UNGRS	833	67.2
COND, AAC BULL 38.25D INSU UNGRS	1300	139
COND, AAC BULL 38.25D UNGRS	1300	139

3.6.5 Safety Clearances

The Substation layout consists essentially in arranging the number of switchgear components in an ordered pattern governed by their function and rules of spatial separation. Spatial Separation refers mainly to:

- Earth Clearance is the clearance between live parts and earthed structures, walls, screens and ground;
- Phase Clearance is the clearance between live parts of different phases;
- Isolating distance is the clearance between the terminals of an isolator and the connections thereto;
- Working clearance: this is the clearance between live parts and the terminals of a work section (maintenance zone), i.e. natural ground or another platform from where an operator will work from;
- Maintenance zones.

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Based on the above factors the following electrical and working clearances were adhered to for the design of the primary plant:

Table 6: Safety clearances

Nominal System Voltage	Highest System Voltage	Minimum Electrical Clearance (Phase to Earth)	Minimum Electrical Clearance (Phase to Phase)	Minimum Working Clearance (Horizontal)	Minimum Working Clearance (Vertical)
11 kV	12 kV	200mm	300mm	1.4m	2.8m
132 kV	145 kV	1450mm	1680mm	2.3m	3.7m

The detailed design herein uses equipment with electrical clearances well above what is required and all working clearances are above the required minimum values.

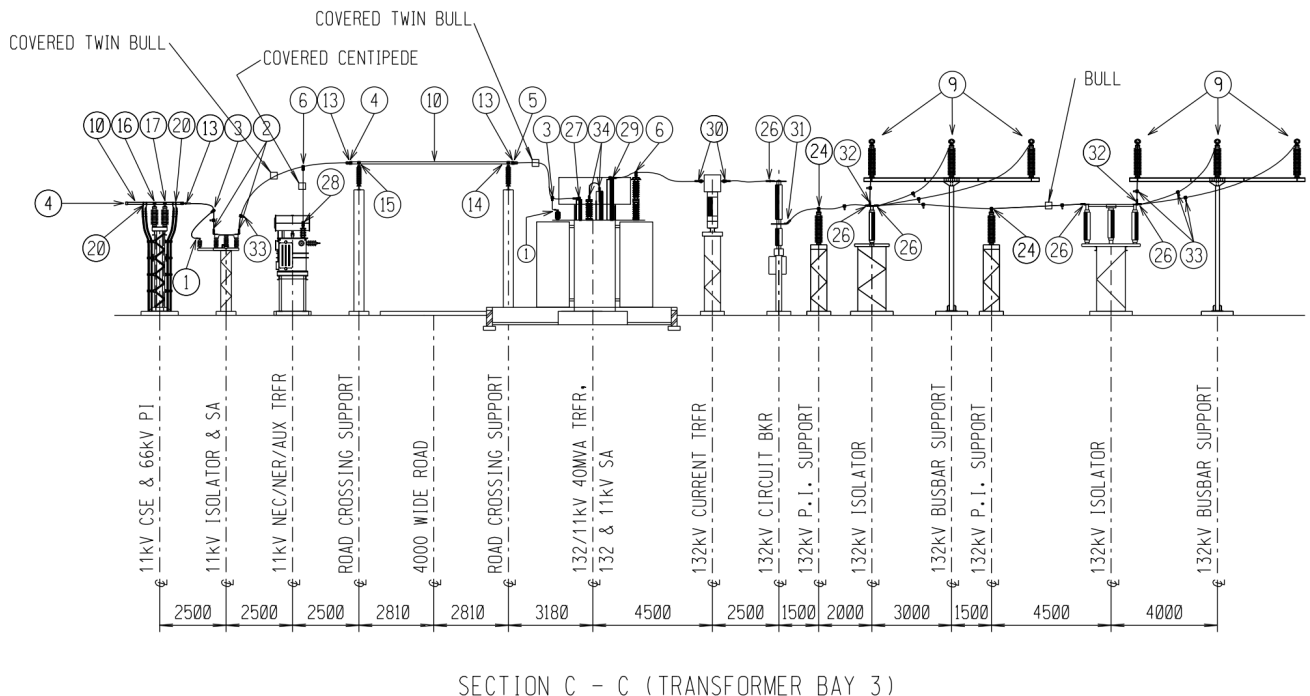


Figure 3: Section view of the 132/11 kV Substation arrangement (Transformer Bay No.3)

3.6.6 Lighting and lightning protection

The new transformer bay will be protected by means of 5x 14m lighting/lightning masts. The final positioning and height of the lightning masts has been determined such that combined masts provide overlapping area so that each outdoor equipment of the new transformer bay is sufficiently covered against lightning strikes.

In order to provide sufficient illumination levels within the area of the new transformer bay, 60W/230V led floodlights and fittings will be installed on each existing 14m masts and on the five new 14m masts.

The existing 400W/230V floodlights from the existing lighting/lightning masts are to be removed and fitted with new 60W/230V led floodlights.

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3.6.7 Earthing

Since Leaches bay is an existing substation, it was necessary to determine its earthmat condition. For this reason, earth resistivity and continuity tests were carried out on site (See appendix A for earthmat investigation and continuity test report.). Furthermore, additional test will be carried out at construction stage to ensure continuity between each existing element and the earthmat.

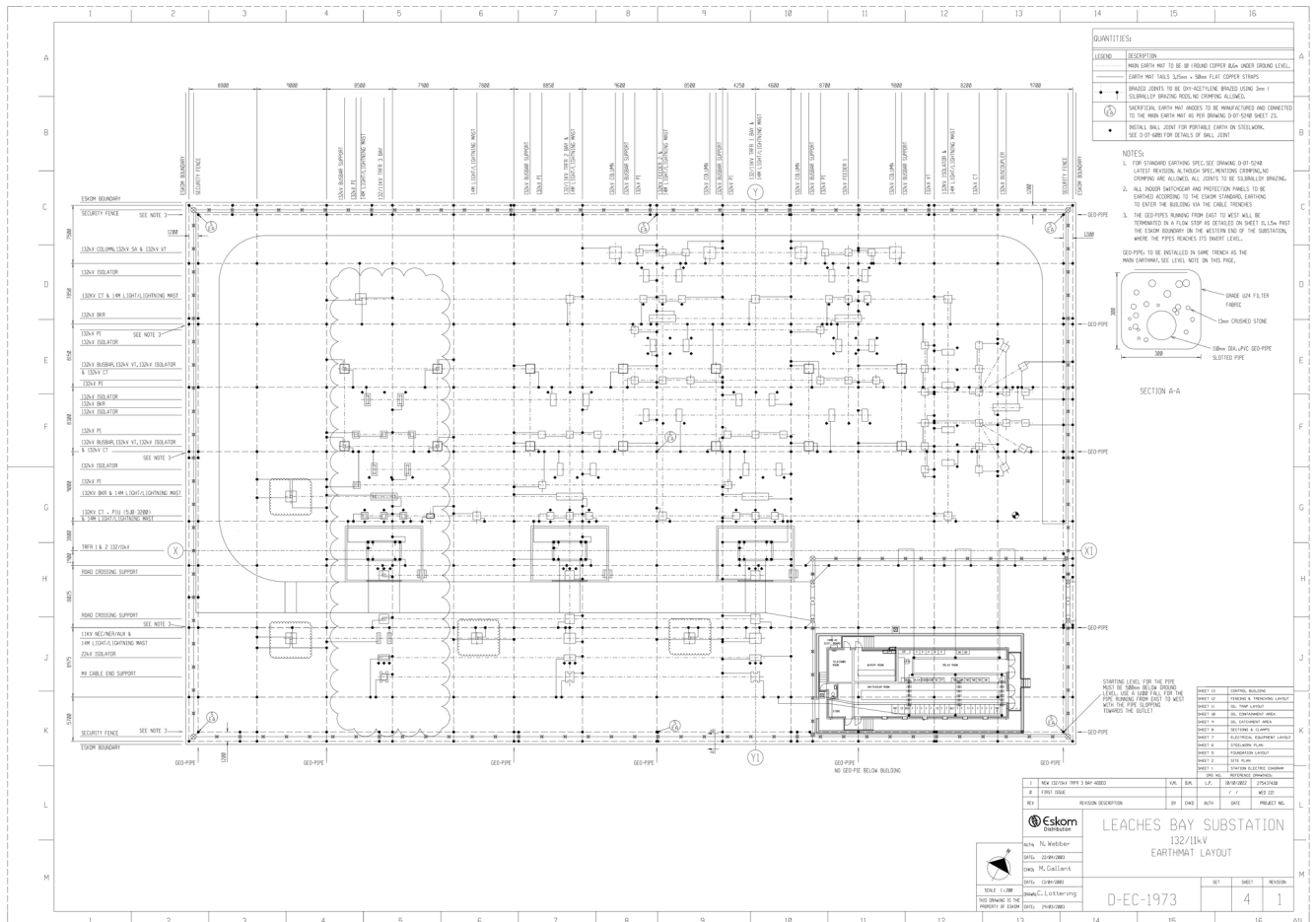


Figure 4: Connecting to the existing earthmat

Furthermore, more copper rods will be added to provide a shorter connection point for new equipment to the existing earth mat. Furthermore, each new equipment will be connected to the earth mat by at least two 50x3mm flat copper straps as indicated in Figure 4. All new equipment are to be earthed using the foundation HD bolts. The earth tails (flat copper) comes on the side of the foundations to the earthmat as indicated on D-DT-5240 Sheet 6 Rev 3. Earthing balls are to be installed on the equipment steelwork supports as detailed on D-EC-1973 Sheet 4 Rev 1. The final position of earthing balls is to be negotiated with the Customer Network Centre.

The existing earthmat and equipment bonding integrity will be assessed. Additional 10mm diameter earth rods on the earthmat has no negative impact on the substation safety.

3.6.8 External Interfaces

The design considers two external interfaces, the connection of East London Industrial Development Zone (ELIDZ) and Buffalo City Municipality (BCM) networks. The power distribution within ELIDZ is achieved at 11kV and distributed using underground cables, Ring Main Units, built up substations and miniature substation. Twelve feeders at Leaches Bay substation are dedicated to the supply of ELIDZ 11kV network and two feeders to supply Buffalo City Metro (BCM) loads.

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3.6.9 Maintenance Concept

Level of on-site repair strategy will be in accordance to Eskom maintenance standards. Spare parts holding strategy in accordance to Eskom standards. The maintenance strategy for all primary plant equipment is included in the approved Eskom specifications for each piece of equipment.

Outage strategy will also be a strategy aligned with Eskom's planning as the customer (ELIDZ) being supplied out of Leaches bay substation has a Premium supply that requires Eskom to handle issues relating to outages in a very sensitive manner.

3.6.10 Operating Concept

The system operation concept is summarised as follows:

Due to different transformation capacities, it is required for the bus section breakers to remain open under normal operating conditions with circuit breaker interlocks to avoid paralleling the 40MVA transformer with the 20MVA transformers.

Due to the abovementioned reason, it is essential for the 40MVA transformer to also operate some load in order to avoid power dissipation by not loading it. Although minimal and nothing should happen to it over time, the following proposed operating concept options will make use of the 40MVA transformer to also supply the loads at least fourteen days per month and then power can also be transferred to the existing 2x 20MVA transformers to also supply the loads for the rest of the days of the month based on the tabulated options below. This process should be repeated every month by the responsible Eskom transformer technician.

- 1 means ON (Close)
- 0 means OFF (Open)
- BS1 stand for "Bus Section 1"
- BS2 stands for "Bus Section 2"
- TCB1 stand for "transformer Circuit Breaker 1"
- TCB2 stand for "transformer Circuit Breaker 2"
- CB1 is the Circuit Breaker at IDZ Transfer FDR 1, 11 kV FDR 16
- CB2 is the Circuit Breaker at IDZ Transfer FDR 2, 11 kV FDR 15
- T1, T 2 and T3 Transformer 1, 2 and 3 respectively.

Table 7: Operating Concept Options

	Options	Supply to the loads	BS1	BS2	TCB1	TCB2	TCB3	CB1	CB2
	Default	T1 & T2	1	0	1	1	1	0	0
Loss of T2	Option 1	T3	1	1	0	0	1	0	0
	Option 2	T1 & T3	0	1	1	0	1	0	0
Loss of T1	Option 3	T2 & T3	0	0	0	1	1	1	1

3.7 CIVIL INFRASTRUCTURE AND BUILDING DESIGN

Leaches bay is an existing substation and therefore this detailed civil design is concerned with new equipment support foundations, extension to cable trenches, excavation, back-filling, compaction and yard stone replenishing.

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3.7.1 Support structures and Foundations

The following types of support structure foundations are part of the detailed design:

- 132 kV Tubular busbar to 5220;
- 132 kV Circuit breaker to D-DT-5200;
- 132 kV Isolators to D-DT-5202;
- NECRT/AUX Transformer to D-DT-5207;
- Medium equipment foundation for CTs and PI's to D-DT-5206;
- Road Crossing to D-EC-1974;
- 22 kV Isolators to D-DT-5205;
- Cable end support to D-DT-5213;
- Lighting/Lightning mast to D-DT-5217 and
- PIU Plinth to D-DT-5416

The steelwork and foundation layouts are given in figure 5 and 6 below. The complete Steelwork and foundation layouts are respectively given in drawing D-EC-1973 Sheet 6 Rev 1 and D-EC-1973 Sheet 5 Rev 2.

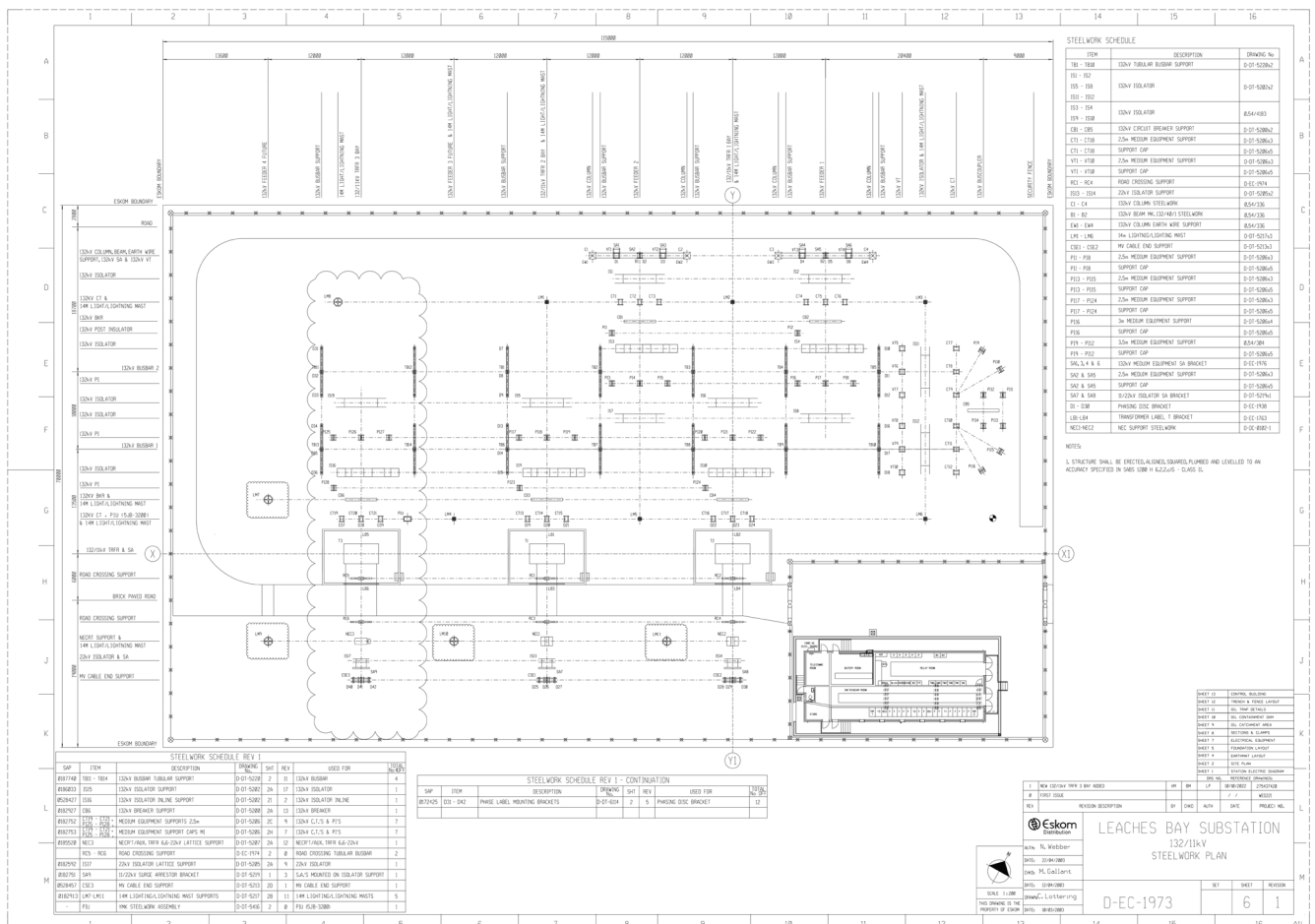


Figure 5: Steelwork Layout for the new 132/11kV Transformer Feeder bay No.3

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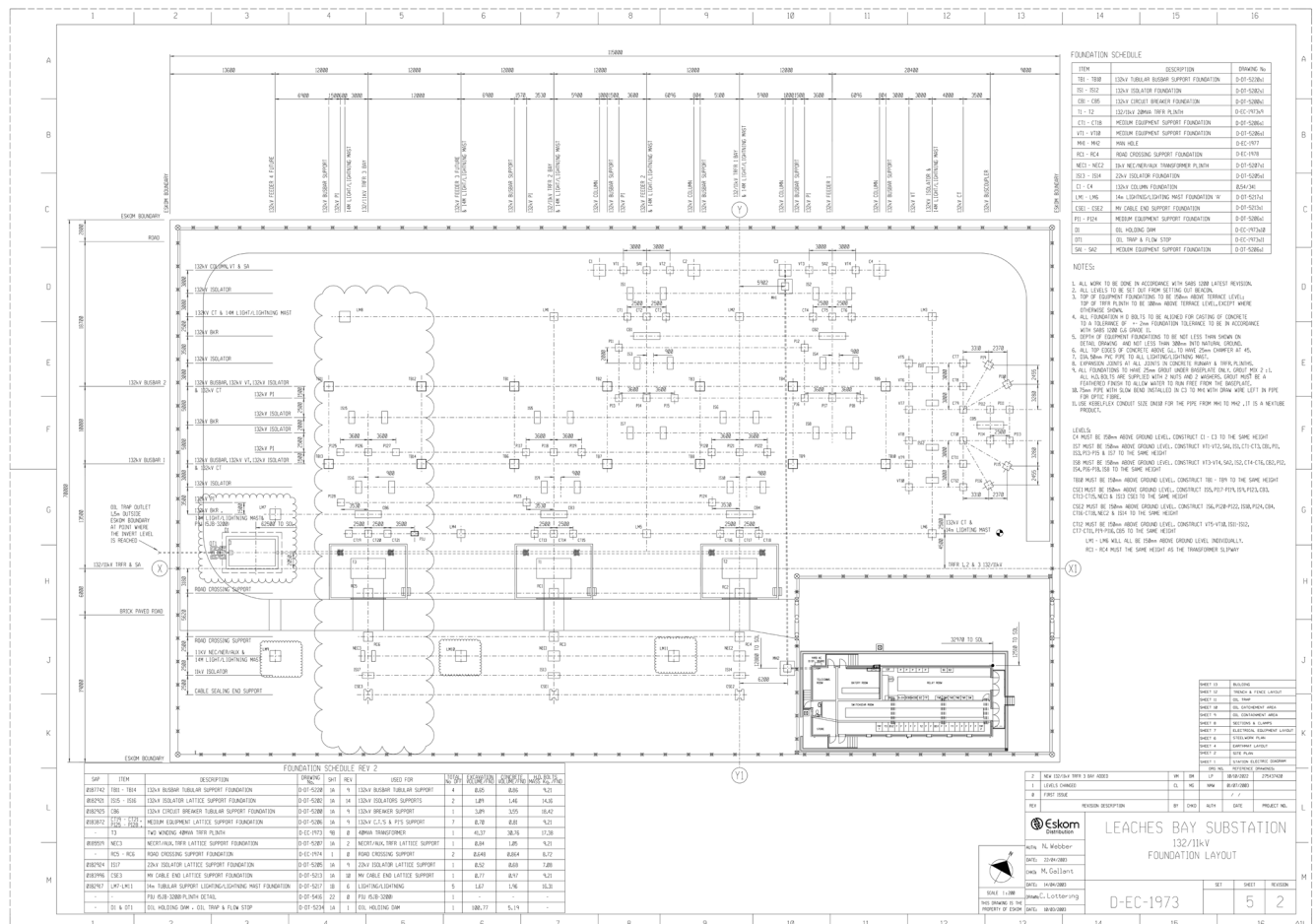


Figure 6: Foundation Layout for the new 132/11kV Transformer Feeder bay No.3

3.7.2 Transformer Plinth

Transformer plinth is designed to Eskom standard. The plinth is designed to carry the weight of a 132/11kV-40MVA transformer. The plinth's floor is sloped in order to ensure that any oil leak is directed towards the sump point. From the sump, the spilt oil is directed to the oil dam through a concrete pipe.

The plinth is designed to support a maximum weight of 72 kg. The thickness of each transformer plinth will be 500mm, the slipways 320mm and the substation runway 320mm.

The Transformer plinth will have a bund-wall area (en-catchment facility) to ensure any oil spilled is encapsulated within the confinement of the bund-wall structure and channeled to a sump which will be connected to the oil holding dam through concrete pipes. The bund-wall height is dependent on the total oil volume of a transformer see drawing D-EC-1973s9B.

3.7.3 Oil Holding Dam

The existing oil dam will be demolished and a new oil dam with the oil capacity of 32 000 litre will be build to accommodate any of the three transformers in case of oil spillage. The Oil-holding dam volume capacity is designed to Eskom standard based on D-DT-5234s1 Rev1 with a 6m width, 3.5m breadth and 1.5m depth.

3.7.4 Cable trenches

For a neat and safe cable laying, additional works are required to extend the existing cable trench network to near each equipment of the transformer bay in conformance to D-DT-5254 and D-EC-1735.

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A snapshot providing a layout of the proposed extension is provided in the figure below.

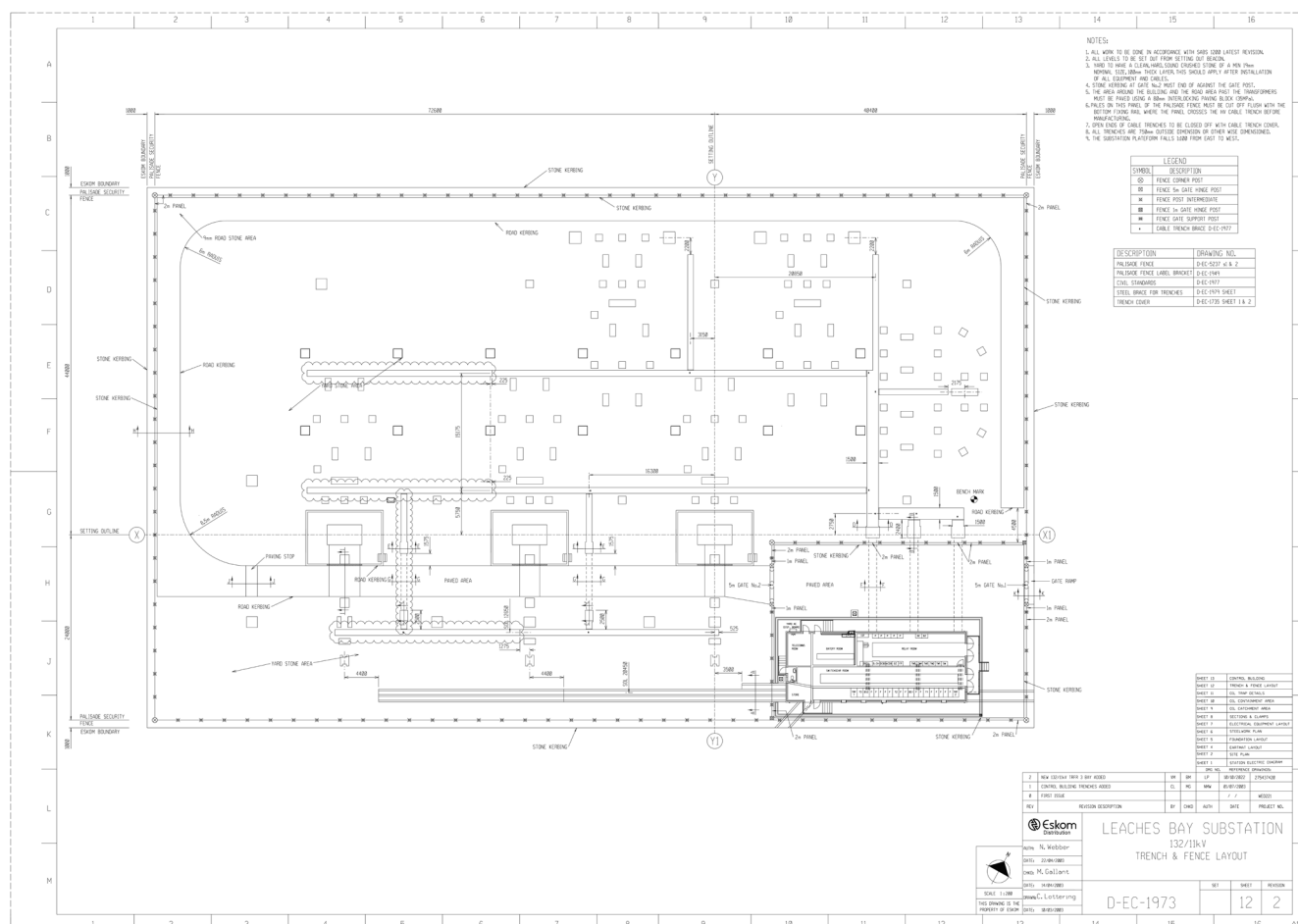


Figure 7: Cable trench layout

It is worth noting that the design does not mix control and power cables. This implies that the power cables are predominantly buried directly in the ground.

3.8 SECONDARY PLANT DESIGN

See Control Plant Design Report

3.9 SYSTEM DESIGN ASSESSMENT

3.9.1 Operability

Substation operations to be according to Eskom approved processes. Changes to the substation shall have no impact on the status quo.

3.9.2 Reliability, Maintainability, Availability

The substation design is to ensure full load supply to East London Industrial Development Zone (ELIDZ) and Buffalo City Municipality (BCM) through transformers T1, T2 and T3.

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3.9.3 Procureability

It is achieved by adhering to Eskom standards and Eastern Cape Operating Unit (ECOU) preferences, including standard material. This is to ensure that existing labour contracts can be used and materials could be easily accessed as it is already used.

3.9.4 Primary Plant Constructability

For the purpose of this project, we shall treat the substation as live and organise tasks accordingly.

Four Outages will be required as follows:

- 1) Phase 1 – Outage No.1 (132 kV busbar extension) – Live Line
 - Extend 132 kV Busbar
 - Battery Charger and Bank Upgrade – Risk of Trip (See control plant report for detail)
- 2) Phase 1 – Outage No.2 (132 kV Transformer No.3) – Live Line
 - Install 132/11 kV 40MVA Transformer No.3
- 3) Phase 2 – Outage No.3 (11kV Busbar Extension & Feeders)
 - 11 kV Bus section
 - 11 kV Transformer Incomer
 - 11 kV Outgoing Transfer Feeder 16
- 4) Phase 3 – Outage No.4 (11 kV Feeder No.15)
 - 11 kV Outgoing Transfer Feeder 15

Given the existence of earth mat in the substation, a small-scale excavator that can operate within a radius of 0.7m shall be used. However, the depth of excavation shall be limited to 0.6m to ensure that the operations do not damage the existing earth grid. The balance of this work shall be by labour intensive manual excavation.

Circulation ways in the substation have sufficient clearance to allow the passage of an excavator on the way to the work area.

The envisaged construction at Leaches bay for the 132/11 kV Transformer feeder No.3 include the following activities listed in order of priority:

- (1) Excavation for foundation and erection of support structure for:

- ✓ 4x 132 kV tubular busbars
- ✓ 2x 132 kV busbar isolators
- ✓ 1x 132 kV circuit breaker
- ✓ 1x 132/11 kV 40MVA transformer
- ✓ 1x 11 kV NECR'T/ AUX transformer
- ✓ 1x 22 KV isolator
- ✓ 1x Cable end support
- ✓ 1x PIU (5JB-3200)
- ✓ 5x 14m lighting and lightning masts;

- (2) Excavation for control technology cable trenches;
- (3) Perform a continuity test on the existing earth mat;
- (4) Foundation Casting for:

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- ✓ 4x 132 kV tubular busbars
- ✓ 2x 132 kV busbar isolators
- ✓ 1x 132 kV circuit breaker
- ✓ 1x 132/11 kV 40MVA transformer (casting of a plinth and building of a transformer bund wall)
- ✓ 1x 11 kV NECR'T/ AUX transformer
- ✓ 1x 22 KV isolator
- ✓ 1x Cable end support
- ✓ 1x PIU (5JB-3200) (Casting of a plinth for the PIU)
- ✓ 5x 14m lighting and lightning masts;

(5) Construction for control technology cable trench network extension;

(6) Erection of support structure and bonding to earthmat for:

- ✓ 4x 132 kV tubular busbars
- ✓ 2x 132 kV busbar isolators
- ✓ 1x 132 kV circuit breaker
- ✓ 1x 132/11 kV 40MVA transformer
- ✓ 1x 11 kV NECR'T/ AUX transformer
- ✓ 1x 22 KV isolator
- ✓ 1x Cable end support
- ✓ 1x PIU (5JB-3200)
- ✓ 5x 14 m lighting and lightning masts;
- ✓ AC distribution yard panel;

(7) Equipment positioning, erection and securing into final position for:

- ✓ 4x 132 kV tubular busbars
- ✓ 2x 132 kV busbar isolators
- ✓ 1x 132 kV circuit breaker
- ✓ 1x 132/11 kV 40MVA transformer
- ✓ 1x 11 kV NECR'T/ AUX transformer
- ✓ 1x 22 KV isolator
- ✓ 1x Cable end support
- ✓ 1x PIU (5JB-3200)
- ✓ 5x 14m lighting and lightning masts;
- ✓ AC distribution yard panel;

(8) Stringing of the new equipment installed with a single bull conductor on the 132 kV and a covered double bull conductor on the 11kV side of the transformer with all clamps specified on clamp schedule.

(9) Extension of the existing 132 kV tubular busbar.

(10) Laying directly in the ground and termination of 1C-4x 630mm² Copper XLPE cables from the cable end support to 11 kV indoor incoming transformer feeder.

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(11) Extension of the existing 11 kV board and installation of additional 1x 11kV-2500A incoming transformer feeder, 1x 11kV-2500A Bus section breaker and 2x 11kV-2500A outgoing transfer feeders.

(12) Termination of 1C-4x 630mm² Copper XLPE cables between the two outgoing transfer feeders.

The following are the schedule of hold points that should be followed during the construction phase:

- Once completion of the preparation work involved in the construction of all equipment and steelwork foundations is imminent, prior to the concrete being cast, the designated Clerk of Works or his delegated representative shall be given satisfactory advance notice of the need to visit site to inspect this form work, i.e. setting out, excavations, foundation centres, levels, alignment, reinforcing, earth connections, etc. It is essential that this stage be observed as a critical “hold point” by the contractor involved and no further work shall continue on this phase of construction, until the necessary inspection has taken place and the work approved accordingly.

NB. Once all foundations have been cast, but prior to any steelwork being erected, a further check must be undertaken by the Clerk of Works, to ensure all associated design criteria has been maintained in the construction of all foundations, and the work approved accordingly.

- Once all jointing is complete and before the earth mat is buried, it is essential that the Project Engineer / Clerk of Works concerned is notified well in advance, so that an inspection of the earth mat and all associated connections to it, is undertaken. The earth mat resistance measurement can be completed at the same time to ensure its acceptability.
- Before any compression joints are applied in the construction of the project, it is considered critical that a “hold point” be observed to ensure the compression joint tools are checked and approved by the Clerk of Works. If deemed necessary by the Clerk of Works, a sample compression joint shall also be performed by the contractor and witnessed accordingly, prior to commencement of the actual project related work, to ensure final compliance with manufacturer’s specifications.
- The onus shall be on the contractor to ensure that the labels received on site comply exactly with the equivalent information specified in the label schedule.
- Furthermore, the contractor shall implement and use the quality check system provided in **Document No. 240-87605434 and Bigen issued quality checklist** throughout the duration of this project. The contractor shall provide regular feedback on all aspects of quality control on the site, which shall constitute a pre-requisite to the final hand-over / take-over stage of the project.

3.10 SYSTEM SAFETY ASSESSMENT

3.10.1 Safety Assessment

Eskom standards are used throughout the design to ensure safety aspects during construction, operation, maintenance, and commissioning.

3.10.2 Environmental Assessment

The new transformer bay will be installed within the existing leaches bay yard thus no significant environmental concern are expected. The Environmental Management Plan Will be covered by the one that has been prepared for Leaches bay substation, but Bigen Environmental consultant will be modifying it to cater for the extension scope.

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For works to be conducted at Leaches bay substation, an EMPr will be produced by the Environmental consultant.

Environmental Aspects to be brought in place for the Construction Phase are as follow:

- EMPr as approved by the Eastern Cape Department
- ✓ Bigen Environmental Consultant will provide a synopsis of the issues to be controlled during the construction phase.
- Appointment of an Environmental Control Offices (ECO)
- ✓ ECO will control the day to day compliance of all environmental aspects in terms of staff; staff environmental training; recording of incidents; adjusting the EMPr as and when required; keeping record of all EMPr documents handed out and signed for; preparing the ECO Report File for its monthly independent audit.
- EMPr as approved to be signed by all contractors as “Proof of Receiving the EMPr”.
- Establishing a Site Office for the construction phase in accordance with the EMPr and the aspects as registered with the Eastern Cape Department.
- ✓ ELIDZ Environmental consultant will provide the guidelines for the site office operation.
- Appointment of an Independent Environmental Control Officer to undertake the monthly environmental compliance audit.
- ✓ ELIDZ Environmental Consultant will provide the service; ensure compliance and provide the required Independent Audit Reports on a monthly basis to the on-site ECO.
- Informing the relevant authorities of the start of the construction phase as well as the start of the operational phase at the appropriate time and date as required.
- ✓ ELIDZ Environmental Consultant will undertake these notifications.

3.11 TEST AND COMMISSIONING STRATEGY

All testing and commissioning will follow the Eskom standard procedures. Eskom shall attend and witness all Factory Acceptance Tests (FAT) and Site Acceptance Tests (SAT). The appointed contractor shall prepare a FAT and SAT plan and communicate this to Eskom well in advance to allow Eskom to make arrangements as required.

The commissioning and Hand-Over of the project shall be done only after a detailed inspection of the asset by the following individuals:

- The Contractor;
- The Project Manager;
- The Clerk of Works;
- The Project Engineer;
- The Environmental Control Officer and the Employers Environmental Official; and
- Field Services and Plant Officials.

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After the final inspection, all defects identified, shall be rectified by the contractor before proceeding with the commissioning and hand-over.

3.12 SECURITY DESIGN

The site is fenced, secure and located on a security guarded and controlled mine property. Therefore, the security risk is bare minimum.

3.13 RISK AND ISSUE REGISTER

The appointed contractor shall finalise the risk and issue register from the one issued by the consultant.

The following is the summary of high priority risks:

Table 8: Summary of high priority risks

Description	Consequences	Priority Rating	Treatment Plan	Owner
Underground Cables	Disruption of supply	90%	Location of existing cable before the excavation	Engineer and Contractor
Material selection	Hot spots and over heating	90%	Proper calculations and specification /standard to be used	Engineer
Ordering of Long lead materials	Construction delay	70%	Before construction all material to be on side	Engineer

4. AUTHORISATION

This document has been seen and accepted by:

Name	Designation

5. REVISIONS

Date	Rev.	Compiler	Remarks
March 2023	1	V. Muamba	First Draft

6. DEVELOPMENT TEAM

The following people were involved in the development of this document:

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7. ACKNOWLEDGEMENTS

Eskom Distribution Network Engineering Team – East London

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APPENDIX A: DETAIL DESIGN OUTPUT DOCUMENTS

EARTH RESISTIVITY TESTING & EARTHMAT DESIGN REPORT

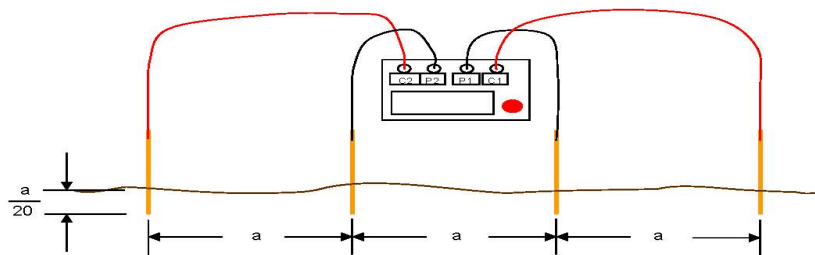
(SEE ATTACHED EARTHMAT DESIGN REPORT)

SITE: LEACHES BAY SUBSTATION (BETWEEN THE FENCE AI) DATE: 24/02/2023

Test Equipment Used		
Instrument	Model/Asset number	Serial Number
Earth Resistivity Meter	SEW /4234 ER	

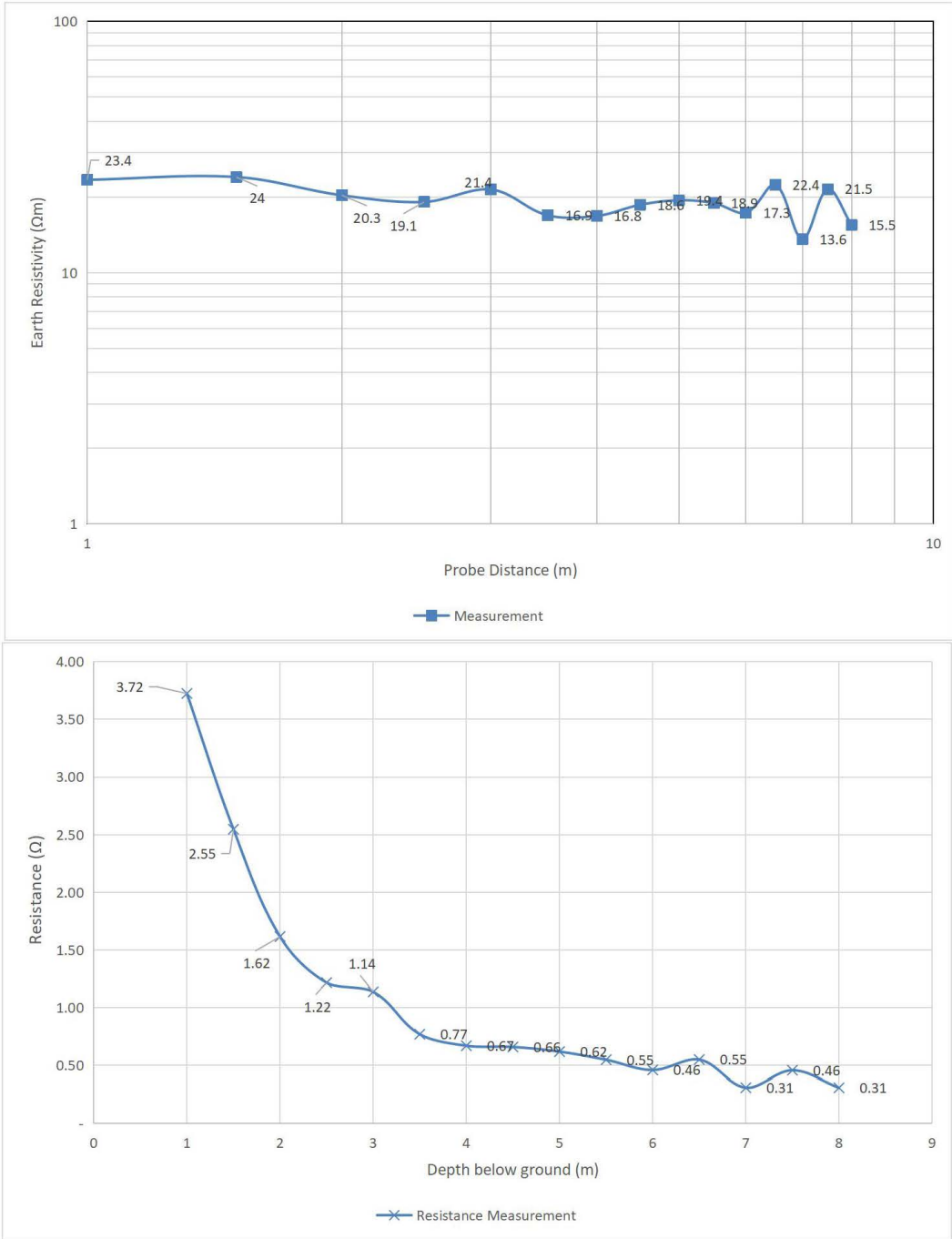
Weather Conditions	Soil Conditions	Soil Type
Sunny <input checked="" type="checkbox"/>	Wet <input type="checkbox"/>	Loam <input type="checkbox"/>
Partly Overcast <input checked="" type="checkbox"/>	Moist <input type="checkbox"/>	Clay <input type="checkbox"/>
Overcast <input type="checkbox"/>	Dry <input checked="" type="checkbox"/>	Sand <input checked="" type="checkbox"/>
Raining <input type="checkbox"/>	Very Dry/Arid <input type="checkbox"/>	Stone/Granite <input type="checkbox"/>
Temperature:		Other:

Row	Time:		Measurement 1		Measurement 2		Measurement 3	
	1:00 PM							
	Probe Spacing (a)	Geometric Factor $2\pi a$	Tester Reading (Resistivity ρ)	Resistance ($R=\rho/2\pi a$)	Tester Reading (Resistivity ρ)	Resistance ($R=\rho/2\pi a$)	Tester Reading (Resistivity ρ)	Resistance ($R=\rho/2\pi a$)
	m		$\Omega.m$	Ω	$\Omega.m$	Ω	$\Omega.m$	Ω
1	1	6.283	23.4	3.72		-		-
2	1.5	9.425	24	2.55		-		-
3	2	12.566	20.3	1.62		-		-
4	2.5	15.708	19.1	1.22		-		-
5	3	18.850	21.4	1.14		-		-
6	3.5	21.991	16.9	0.77		-		-
7	4	25.133	16.8	0.67		-		-
8	4.5	28.274	18.6	0.66		-		-
9	5	31.416	19.4	0.62		-		-
10	5.5	34.558	18.9	0.55		-		-
11	6	37.699	17.3	0.46		-		-
12	6.5	40.841	22.4	0.55		-		-
13	7	43.982	13.6	0.31		-		-
14	7.5	47.124	21.5	0.46		-		-
15	8	50.265	15.5	0.31		-		-
16						-		-
17						-		-
18						-		-



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APPENDIX B: SUBSTATION MAJOR DRAWINGS

D-EC	Title	SHT	Rev.
SUBSTATION LAYOUT			
D-EC-1973	Station Electric Diagram	1A	5
D-EC-1973	Station Electric Diagram -Transformer 1 Incomer	1B	5
D-EC-1973	Station Electric Diagram -Transformer 2 Incomer	1C	4
D-EC-1973	Station Electric Diagram -Transformer 3 Incomer	1D	0
D-EC-1973	Site Plan & Future Extension	2	1
D-EC-1973	Earthmat Layout	4	1
D-EC-1973	Foundation layout	5	2
D-EC-1973	Steelwork Layout	6	1
D-EC-1973	Electrical Equipment Layout	7	1
D-EC-1973	Sections & Clamps	8	1
D-EC-1973	Transformer 3 Plinth Detail with Oil Catchment Area	9B	0
D-EC-1973	Existing Oil Trap Details	11	1
D-EC-1973	Trench & Fence Layout	12	1
D-EC-1973	Yard Lighting Layout	20	0
D-EC-1973	Lightning Protection Layout	21	0
D-EC-1735	Precast Concrete 750mm Trench Cover	1	4
D-EC-1735	Precast Concrete 1500mm Trench Cover	2	2
D-EC-1974	Road Crossing Support Foundation Details	1	0
D-EC-1974	Road Crossing Support Steelwork Manufacturing Details and Assembly	2	0
CONTROL BUILDING			
D-EC-1973	Control Building Detail Plan Section and Elevations	13	1
D-EC-1973	Control Building Electrical Layout	14	2
D-EC-1973	Control Building Door, Window Schedule and Detail	15	1
D-EC-1973	Control Building Section and Specifications	16	1
D-EC-1973	Control Building Trench Cover Layout and Details	17	1
D-EC-1973	Control Building Distribution Board and Sub-Distribution Board Diagrams	18	2
D-EC-1973	Control Building Typical Detail of Ducting Entry into Building	19	1
D-SR-121	Control Building Switchgear Room and Relay Room Panel Arrangement	03	1

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APPENDIX C : FOUNDATIONS DRAWINGS

D-DT	Title	SHT	Rev.	SAP
D-DT-5220	Tubular Busbar - 132kV 3m Phase CRS Single Tubular Support Foundation Details	1A	9	0187742
D-DT-5200	Circuit breaker - 132kV Tubular support foundation details - cable pipe	1A	9	0182925
D-DT-5202	Isolator - 132kV 3 & 3.6m phase CRS Lattice support foundation details	1A	14	0182921
D-DT-5206	Medium equipment lattice support foundation details	1A	9	0183872
D-DT-5217	Lighting - lightning mast - 14m Tubular support foundation details	1B	6	0182917
D-DT-5207	NECR'T/ AUX.TRFR 6.6-22kV Lattice Support Foundation Details	1A	2	0185519
D-DT-5205	Isolator - 22kV 1m Phase CRS Lattice Support Foundation Details	1A	9	0182924
D-DT-5213	MV Cable Sealing End Lattice Support Foundation Details	1A	10	0183996
D-DT-5416	PIU (5JB-3200) Plinth Detail	22	0	
D-DT-5234	Oil Holding Dam	1A	1	

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APPENDIX D: STEELWORK DRAWINGS

D-DT	Title	SHT	Rev.	SAP
D-DT-5200	Circuit breaker - 132kV Tubular support steelwork manufacturing details	2A	13	0182927
D-DT-5202	Isolator STD - 123kV Manual lattice support steelwork manufacturing details and assembly	2A	17	0186033
D-DT-5202	Isolator Inline - 123kV Manual lattice support steelwork manufacturing details and assembly	2I	2	0528427
D-DT-5206	Medium equipment - 2.5m Lattice support steelwork manufacturing details and assembly	2C	9	0182752
D-DT-5206	Medium equipment - Cap M1 Channel support steelwork manufacturing details and assembly	2H	7	0182753
D-DT-5217	Lighting - lightning mast - 14m Tubular support steelwork manufacturing details and assembly	2B	11	0182913
D-DT-5220	132kV Tubular Busbar Support Details	2	11	0187740
D-DT-5207	NECR'T/AUX.TRFR 6.6-22kV LATICE SUPPORT-0.4 & 1.5m Steelwork Manufacturing Details	2A	12	0185520
D-DT-5205	Isolator STD - 22kV Manual Lattice Support Steelwork Manufacturing Details and Assembly - 1m Phase CRS	2A	9	0182592
D-DT-5219	Surge Arrestor Bracket 11/22kV Mounted on Isolator Support	1	3	0182751
D-DT-5213	MV Cable End Support 2 OR 4 x Single Core Cable/Phase Lattice Support Steelwork Manufacturing Details and Assembly	2D	1	0528457
D-DT-5416	PIU Steelwork Assembly	22	0	

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APPENDIX E: EQUIPMENT LAYOUT DRAWINGS

D-DT	Title	SHT	Rev.	SAP
EQUIPMENT SPECIFICATION (OUTDOOR PLANT)				
D-DT-6230	INSUL:STN POST;C4-550;132 KV	1	7	0017528
D-DT-6302	ISO,EL:132 KV ;2500 A ;40 KA ;HAND ;0ES	1	5	0642560
D-DT-6302	ISO,EL:132 KV ;2500 A ;40 KA ;INLHAND	4	5	0642796
D-DT-6250	BKR:LT;132 KV;3150 A;40 KA;3;110 VDC	1	14	0642972
D-DT-6190	CT 132kV 2500A 40kA 2P2M2B1600 31	1	11	0180034
D-DT-6210	S/ARR S/CL 132kV MCOV 84kV 31	1	10	0400380
D-DT-6120	TRFR 40MVA 132/11kV OLTC (SI) YNd1 31	2	8	0193830
D-DT-6216	S/ARR S/CL 11kV MCOV 12kV	1	10	0401605
D-DT-6140	NEC/NER/AUX TFR 11kV 360A 31	1	10	0182730
D-DT-6305	ISO:22 KV;2500 A;31.5 KA;H/O;0ES;110 VDC	1	3	0642550
D-DT-6009	FLDLIGHT:LED;ALUMINIUM;60 W;7200 LM;FLT	1	1	0658980
D-DT-6232	INSUL:STN POST;C4-325;66 KV	1	7	0017527
D-DT-5416	PIU (5JB-3200)		0	
EQUIPMENT SPECIFICATION (INDOOR BREAKER PANEL)				
D-DT-6258	11kV Incomer Breaker Panel 2500A 25kA	3	7	0170210
D-DT-6258	11kV Bus-Section Breaker Panel 2500A 25kA	3	7	0170209
D-DT-6258	11kV Feeder Breaker Panel 2500A 25kA	3	7	0170210
D-DT-6175	11kV VT 11kV/110 50VA cl0.2 (2500A) BUSBAR	2	11	0239686
	11kV CT 2500A 25kA 2P PX FDR			
	11kV CT 2500A 25kA 3P PX TRFR			

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APPENDIX F: EARTHING DRAWINGS

D-DT	Title	SHT	Rev.
D-DT-6044	10mmØ Round Copper Bar	1	5
D-DT-6045	50mm x 3mm Flat Copper Bar	1	4
D-DT-5240	Strip galvanised steel 6 x 80mm	5	3
D-DT-6366	26mm dia Yard stone	1	0
D-DT-5240	Earthing Standard General Notes	1	5
D-DT-5240	Earthing Standard Copper Joints Details	2	3
D-DT-5240	Earthing Standard Earthing through Foundation with uPVC pipe from 25-40kA	3	3
D-DT-5240	Earthing Standard Typical Equipment Foundation Detail	6	3
D-DT-5240	Earthing Standard Typical Support Earthing Detail	6C	0
D-DT-5240	Earthing Standard Post Type VT, CT, and JB Earthing Detail	7	2
D-DT-5240	Earthing Standard Typical Isolator with Surge Arrestor with Surge Arrestor Earthing Arrangement	8	2
D-DT-5240	Earthing Standard Safety Fence Earthing Detail	9	4
D-DT-5240	Earthing Standard Reinforcing Earthing Detail	10	2
D-DT-5240	Earthing Standard Sacrificial Earth Grid Anode Detail	11	2
D-DT-5240	Earthing Standard Earth Strap Fixing Detail	12	2
D-DT-5240	Earthing Standard Earthing of Switch Gear	13	2
D-DT-5240	Earthing Standard Control Panel Earthing Detail	14	3
D-DT-5240	Earthing Standard Armoured Telephone and Screened Control Cables at Junction Box	15	2
D-DT-5240	Earthing Standard Armoured Multicore Control and Telephone or G.P.O. Unarmoured Type Z cable	16	2
D-DT-5240	Earthing Standard Earthing of Telephone or process control cable	17	2
D-DT-5240	Earthing Standard Earthing of Signal Distribution Frames	18	2
D-DT-5240	Earthing Standard MV 3-core cable termination at transformer/NECRT	19	3
D-DT-5240	Earthing Standard Subsoil Trench Detail	22	0
D-DT-5240	Earthing Standard Earth Grid Trench Detail	23	0

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APPENDIX G: SUBSTATION EQUIPMENT LABELS

D-DT	Title	SHT	Rev.
D-DT-5047	Electrical Equipment Labels Size and Legend Layout	2	3
D-DT-5047	Electrical Equipment Labels Fibreglass Manufacturing Details	4	3

LABEL WORDING	LETTER SIZE mm	LABEL TYPE AND SIZE mm	MATERIAL	LETTERING COLOUR	BACKGROUND COLOUR	QUANTITY
PHASE LABELS						
R	100	5 180 x 150	Chromadek	BLACK	RED	4
W	100	5 180 x 150	Chromadek	BLACK	WHITE	4
B	100	5 180 x 150	Chromadek	BLACK	BLUE	4
TRANSFORMER FEEDER 3 – 132 kV SIDE						
TRFR 3 132 kV B/B 1 ISOL	50 30	3 600 x 250	Fibreglass	BLACK	ORANGE	1
TRFR 3 132 kV B/B 2 ISOL	50 30	3 600 x 250	Fibreglass	BLACK	ORANGE	1
TRFR 3 132 kV BRK	50 30	3 600 x 250	Fibreglass	BLACK	ORANGE	1
TRFR 3 132 kV CT	50 30	3 600 x 250	Fibreglass	BLACK	ORANGE	1
TRFR 3 132 kV CT JB	50 30	3 600 x 250	Fibreglass	BLACK	WHITE	1
TRFR 3 132/11 kV	50 30	3 600 x 250	Fibreglass	BLACK	ORANGE	1
132 kV BUSBAR 1	50 30	2 1000 x 250	Fibreglass	BLACK	ORANGE	2
132 kV BUSBAR 2	50 30	2 1000 x 250	Fibreglass	BLACK	ORANGE	2
TRANSFORMER FEEDER 3 – 11 kV SIDE						
TRFR 3 11 kV/400 V NECRT 3	50 30 30	3 600 x 250	Fibreglass	BLACK	ORANGE	1
TRFR 3 22 kV B/B 1C ISOL	50 30	3 600 x 250	Fibreglass	BLACK	ORANGE	1
CIRCUIT BREAKER – 11 kV INDOOR						
TRFR 3 11 kV BKR	10 10	35 x 150	Trafolyte or PVC UV	BLACK	WHITE	1
BUSBAR 1C 11 kV VT	10 10	35 x 150	Trafolyte or PVC UV	BLACK	WHITE	1
BUS-SECTION 2 11 kV BKR	10 10	35 x 150	Trafolyte or PVC UV	BLACK	WHITE	1
IDZ FDR 15 11 kV BKR	10 10	35 x 150	Trafolyte or PVC UV	BLACK	WHITE	1
IDZ FDR 16 11 kV BKR	10 10	35 x 150	Trafolyte or PVC UV	BLACK	WHITE	1

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APPENDIX H: CONDUCTOR & CLAMP SCHEDULE

D-DT	Title	SHT	Rev.	SAP
CONDUCTOR				
D-DT 3136	COND, AAC HORNET 16.25D INSU UNGRS	8	13	0403059
D-DT 3136	COND, AAC CENTIPEDE 26.45D INSU UNGRS	8	13	0403061
D-DT 3136	COND, AAC BULL 38.25D INSU UNGRS	8	13	0403063
D-DT 3136	COND, AAC BULL 38.25D UNGRS	7	13	0403047
D-DT 6000	TUBE :BUSBAR; LG 12M;OD 120mm; ID 112mm	1	5	0206318
ALUMINIUM CONDUCTOR CLAMPS				
D-DT-3074	LUG,AL HORNET 1B M12 0 DEG I/C	2	8	0165839
D-DT-6109	CLAMP:EYC-T;COMP/PALM 90DG;2X38.3 MM	2	7	0005705
D-DT-6002	CLAMP:EX-C;BOLT/BOLT; STEM 38 COND 16.3	2	6	0401788
D-DT-6115	CLAMP, PEG AL BULL 38.3mm EPC-38	1	2	0401655
D-DT-6002	CLAMP:EX-D;BOLT/BOLT; STEM 38 COND 26.5	2	6	0401740
D-DT-6002	CLAMP:EX-B;BOLT/BOLT; STEM 26 COND 26.5	2	6	0401584
D-DT-6013	CLAMP:EYC-B;2X38.3 COMP 38 BOLTED 0DG	2	10	0005663
D-DT-6006	CLAMP:EXC-C;BOLT/COMP; STEM 38 COND38.3	2	9	0005660
D-DT-6002	CLAMP:EX-E;BOLT/BOLT; STEM 38 COND 38.3	2	6	0401635
D-DT-6018	CLAMP:EPC-D;COMP/PALM ODG;38.3 MM	3	8	0400422
D-DT-6018	CLAMP:EPC-E;COMP/PALM 45DG;38.3 MM	3	8	0400425
D-DT-6029	CLAMP:EXCP-D;PI MOUNT;38.3 MM;PCD 127	2	6	0401679
D-DT-6018	CLAMP:EPC-F;COMP/PALM 90DG;38.3MM	3	8	0560892
D-DT-6081	JOINT, BALL PORTABLE EARTH 20kA G/S	1	8	0206118
ALUMINIUM TUBULAR BUSBAR CLAMPS				
D-DT-6090	CLAMP,TUBE:ETP-TE-IL2-R;120/2X38.3;0D	6	8	0206328
D-DT-6040	CLAMP,TUBE:ETEC-DC-C;120/4;38.3C-ENDCAP	5	6	0206320
D-DT-6040	CLAMP,TUBE:ETEC-PL-C;120/4;PLAIN- ENDCAP	2	6	0206319
D-DT-6000	TUBE:BUSBAR;LG 12 M;OD 120 MM;ID 112 MM	1	5	0206318
D-DT-6039	CLAMP,TUBE:ESC-PI-F-F;120/127;FIXED	2	8	0213925
D-DT-6316	CLAMP,TUBE:ESC-PI-S-F;120/127;SLIDE	2	2	0242920
D-DT-6119	CLAMP,TUBE:ETP-IL1-J;120/38.3;SINGLE	2	4	0206097
D-DT-6117	CLAMP,TUB BUS/PALM T/OFF TBPT120	1	3	0206345

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